

Sources of spread in the CMIP3 multi-model projections of the Greenland ice-sheet surface mass balance

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The many studies investigating the future change of the Greenland ice-sheet surface mass balance from climate model output exhibit a wide range of projections. This study explores the underlying physical processes. Our estimate suggests that about 61% of the intermodel difference in the 21st century ablation rate change under the SRES A1B scenario is accounted for by the global annual mean temperature change. In the current study, other processes responsible for the spread in model projections are investigated after excluding this global effect. A negative correlation (-0.60) was found between the simulated summer temperature bias over the Greenland ice sheet under present-day conditions and ablation rate increase during the 21st century because warming in climate models is approximately limited by the melting temperature. Models with relatively larger ablation rate increase during the 21st century exhibit greater warming with a greater reduction in sea ice cover. We found that these models also simulate relatively cooler summer conditions in high latitudes with more sea ice cover in the late 20th century, suggesting the importance of sea ice feedback. We also found an anti-correlation (-0.75) between weakening of the Atlantic meridional overturning circulation and ablation rate increase during the 21st century. The relation in the model spread between the 21st century ablation change and the late 20th century climate conditions found is then used to interpret the multi-model ensemble of projections. According to this relation, the ensemble mean provides a reasonable estimate of ablation considering the model temperature bias but underestimates it in terms of bias in sea ice cover. These results emphasize the importance of correctly simulating the present-day conditions and of understanding the underlying multiple physical processes behind the intermodel difference in order to reduce the uncertainty in the future projections.